## The *Picturephone*® System:

# The 850A PBX

By H. P. ANDERSON

(Manuscript received September 21, 1970)

*In this paper we describe the system organization, operation, and apparatus of the 850A PBX, a* Picturephone® *Switching System. The objectives of the 850A PBX in the Bell System* Picturephone *service plan and the design approach taken are discussed.*

## I. INTRODUCTION

### 1.1 *General*

For business people, person-to-person conversation is the most complete means of communicating; therefore, the first major users of *Picturephone* service are likely to be business persons.

Switching systems such as a Private Branch Exchange (PBX), or a key telephone arrangement are an integral part of most business communications set-ups. To obtain full utilization of the existing telephone network, *Picturephone* service is to he added as an integral part of telephone service; therefore, *Picturephone* service must he added to these systems serving the business community.[1] The 850A PBX has heen designed to provide *Picturephone* service to customers served hy 701B or 757A electromechanical PBXs.

### 1.2 *Objectives*

The objective of the 850A PBX is to provide *Picturephone* service on 701B and 757A types of electromechanical PBXs, step-hy-step (SXS) and crossbar (X-har) respectively, with a common machine. In addition, the 850A PBX is to provide the same services on *Picturephone* service that the customer has on telephone; therefore, the 850A provides *Picturephone* service on all the Communications Service Packages, series 100, 200, 300 and centrex (CU) I and II.

Flexihility of the 850A in working with either SXS or X-bar PBXs is achieved hy using the 850A in parallel with the existing customer telephone switching system. In the 850A *Picturephone* telephone sys-

tem, normal telephone calls generated at a *Picturephone* station are switched to and carried by the telepbone switching equipment; all *Picturephone* traffic (including tbe audio) is processed by the 850A. Because of tbis parallel operation, the 850A performs the same switching functions required by a voice PBX, and it bas tbe additional circuits required for video switching and transmission. Since tbe 850A is a complete PBX, it can be modified to operate as a stand-alone *Picturephone* PBX, i.e., provide only *Picturephone* service to a customer if he so desires.

The 850A PBX is a solid-state machine utilizing a building-block equipment arrangement which allows for easy growth from 16 to 89 *Picturephone* lines. Growable switching networks are obtained by the use of plug-in ferreed packages. Special maintenance features include in-service checks such as guaranteeing a good loop to a *Picturephone* station, before connection and ringing on incoming calls.

Tbe 850A trunk circuits bave been designed to operate over PBX loop ranges up to 2000 ohms and are compatible witb Unigauge Central Office (CO) lines. Allocation of impairments on the video transmission of the 850A are given in Ref. 2. The 850A has video equalizers on the receive pair from each station and each CO line. A Key Telephone System (KTS) equalizer is used in the attendant video loop, this equalizer is used to provide video loopback independent of the optional attendant display set.

To achieve low manufacturing costs, the logic and circuit pack sizes were chosen to be the same as a high production PBX—tbe 800A.[3]

The utilization of this system with tbe major electromecbanical PBXs and the similarity of the apparatus with other electronic PBXs allow uniformity of manufacture, installation, and maintenance.

## II. SYSTEM DESCRIPTION

### 2.1 *General System Arrangement*

A block diagram of the *Picturephone* PBX system is shown in Fig. 1.

*Picturephone* station equipment[4] consists of a 12-button *Touch-Tone*® telephone, a display unit, and a control unit. The 12-button *Touch-Tone* telephone is required for *Picturephone* service. The *Picturephone* service user initiates a video call by pressing the 12th button designated #, and then "dials" the regular telephone number of the person he is calling. A normal voice-only call is originated in

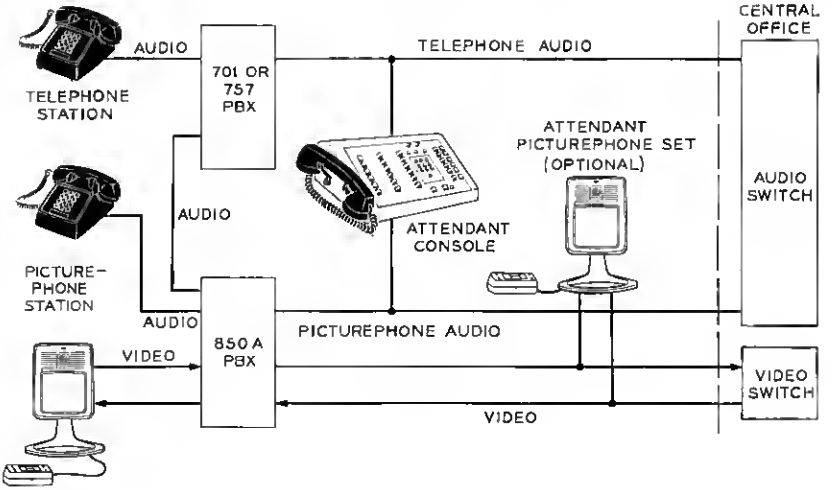


Fig. 1—System interconnection plan.

the usual manner by dialing the number without the # prefix. An incoming *Picturephone* call is characterized by a distinctive ring created hy a tone ringer.

In the initial phase of *Picturephone* service, only the No. 5 crossbar central office will be modified to switch video calls; this capability will also be provided by the No. 1 Electronic Switching System (ESS) in the future. *Picturephone* service customers served by other types of telephone central offices such as panel, SXS, etc., will have their *Picturephone* facilities routed to the nearest No. 5 or No. 1 ESS office modified for *Picturephone* service.

No modifications are required on the existing 2-wire voice loops that connect a customer's telephone to the on-premise switching equipment. The ON-OFF switchhook signals, *Touch-Tone* dialing signals, and the voice portion of *Picturephone* calls are transmitted over the voice pair. In addition, two pairs of wires in the standard telephone cables are assigned for the transmission of the video portion of the call, one pair for the transmission in each direction. Video equalizers[5] are inserted at approximately one-mile intervals between the PBX and the central office. A *Picturephone* call to the local central office is established over a dedicated six-wire *Picturephone* trunk. At the local central office, the voice pair is connected to the existing telephone switch in the conventional way. The video quad is con-

nected to a separate four-wire switch which is controlled by the telephone switching system; the audio pair of this six-wire trunk is never used for voice-only traffic.

All the peripheral equipment and systems to the 850A are discussed in detail in other articles in this issue.

#### 2.1.1 *System Operation*

To illustrate the operation of the system shown in Fig. 1, when a call is initiated by an "off-hook," the two-wire audio loop is connected to the register circuit of the 850A and to a line finder or register in the associated PBX, causing dial-tone to be returned to the station user. The detection of the first "dialed" character as an # by the 850A register causes this system to dismiss the regular PBX and to apply a busy indication to the line appearance in the telephone system. Outgoing *Picturephone* calls are carried over the dedicated six-wire trunk and processed by the central office (the central office does not require a # signal in this case since this equipment can only be seized by a *Picturephone* call). Alternatively, if the called number is not prefixed by #, the 850A register releases itself and applies a busy indication on the 850A line appearance. The call will then be handled as a normal voice-only telephone call in the usual manner by the associated PBX. A regular Direct-Outward-Dialed (DOD) telephone call initiated by a *Picturephone* station, after processing by the associated PBX, will he connected via the regular audio trunk to the serving telephone central office.

850A *Picturephone* lines can also be voice-only extensions equipped with either a *Touch-Tone* or a rotary dial to provide such services as secretary's pickup. A video call can be answered on such an extension; however, in this case, the caller will have a blank screen until the call is picked up by a *Picturephone* set. Rotary dial extensions can only initiate telephone calls but can transfer a *Picturephone* call to another *Picturephone* line by calling the attendant who, in turn, will effect the transfer.

Options which are selected by the customer include attendant video capability and a Video-Image-Generator (VIG) which transmits a fixed image to the calling party while the attendant processes his call.

### 2.2 *Common Control*

The 850A PBX is a solid-state wired-logic, common control switching system, the block diagram of which is shown in Fig. 2.

The common control is an asynchronous circuit with the exception

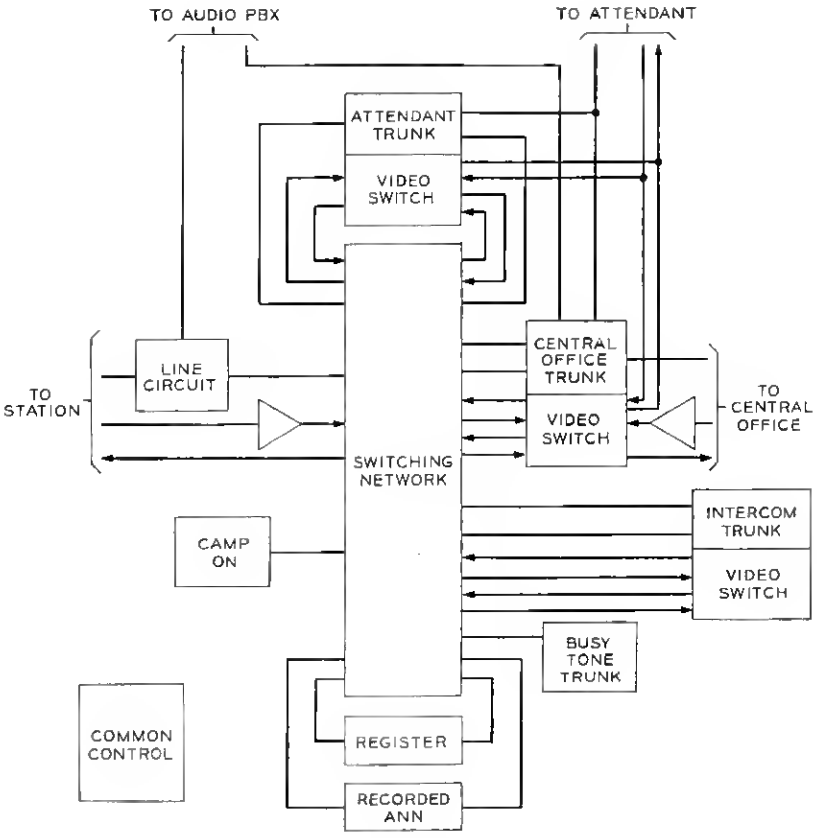


Fig. 2—The 850A PBX block diagram.

of the line-scanner portion which is clocked at a 10 kHz rate. The common control provides the necessary logic for establishing connections between *Picturephone* service circuits through the *Picturephone* switching network.

A "service circuit," such as a line circuit, trunk, register, etc., bids for the common control which determines the mode of operation necessary to provide service to this circuit. After identifying the requesting circuit, the common control locks out all other requests until the initial request has been satisfied. The common control examines the available data from the requesting circuit, marks it on the switching network, and determines what other service circuits, if any, are needed to satisfy the request. An idle circuit of the type requested is selected and also marked on the network. With the two marks on the opposite

sides of the network, the common control enables the network control which establishes the connection. The common control then resets and is ready to receive the next request.

The common control is normally in the idle state. From the idle state, the common control can enter four different functional modes to serve requests. These modes in order of service preference are: read-register (RR), line-dial tone (LDT), camp-on readout (CORO), and attendant-trunk release (ATR). A preference order is assigned to the functional modes in case of simultaneous requests. During the handling of multiple calls, the most important type of request is served first.

The read-register mode is requested by a register when its contents are ready for readout. Readout occurs when the register has the complete number of digits (3 or 4), or a recognizable 1-, 2-, or 3-digit code, or if the register has timed out. The RR mode involves the connecting of the calling circuit to the called circuit.

Line-dial tone mode is requested by circuits that require a register connection. Scanning is required because of multiple circuits requesting service at the same time. These requests include: stations going off-hook, DID trunk seizures by the central office, call-transfer-individual, dial-conference, and attendant trunk seizures. During the LDT mode, requesting circuits are connected to a register through the switching network.

The Camp-On feature is standard with PBX series 200 and 300 and optional with Centrex I and II. Therefore, the camp-on mode is provided only when it is required, and is requested by the camp-on circuit periodically when there is a number stored in one of the three camp-on stores. The CORO mode checks the state of the stored line, and if idle, connects the camped-on trunk to that line.

Attendant-trunk release mode is requested by the attendant trunk when the attendant releases from the trunk and both sides of the trunk are connected to other circuits through the switching network. The function of the ATR mode is to release the attendant trunk from the connection and to establish a new network connection directly between the two circuits previously connected to the attendant trunk.

In addition to providing the logic for the connection of service circuits, the common control performs other functions associated with *Picturephone* calls.

One of these additional functions is related to the identity of a *Picturephone* station. All *Picturephone* stations in the system must be assigned to the same hundreds group of numbers; this hundreds group

is variable from system to system. Any video call to a number not in this hundreds group, e.g., a telephone number or a vacant code, is routed to an intercept-recorded announcement. A listed-directory number (LDN) option is provided wbich allows the LDN for a Centrex-CU System to be in a different hundreds group.

The common control ascertains the class-of-service of a particular *Picturephone* line. Each *Picturephone* station may be assigned to any one of six classes of service. These classes are: CO nonrestricted, dial-conference nonrestricted; CO nonrestricted, dial-conference restricted; CO toll-diverted, dial-conference nonrestricted; CO toll-diverted, dial-conference restricted; CO restricted, dial-conference nonrestricted; CO restricted, dial-conference restricted. One additional class-of-service is provided for use by *Data-Phone*® stations. This data class-of-service is limited to *Data-Phone* stations and is always dial-conference restricted.

Common control also determines wben a video-continuity test (VCT) should be made on an established connection. If the video path does not pass this test, the common control will cause the calling party to be routed to an intercept-recorded announcement; this is the same intercept that is used for calls to vacant codes and the wrong hundreds group.

Station hunting is also controlled by the common control. *Picturephone* stations may be arranged for one-way or two-way hunting as required to be consistent with the telephone PBX.

The common control is arranged for automatic reset under certain abnormal conditions. If any operation takes longer than an expected amount of time, the common control resets. If the common control fails to reset, or the network relays fail to return to normal, a major alarm signal is sent to the Fuse, Alarm, and Emergency Transfer Circuit, resulting in the transfer of all *Picturephone* lines not in use at the time to the existing telephone switching system, thus providing at least telephone communications.

### 2.3 *Register*

Dial Pulse and *Touch-Tone* phone reception is accomplished in the 850A by the register circuit. Connections to tbe register are made through the switching network. Line-side circuits are connected to trunk-side terminations of registers, and trunk-side circuits are connected to line-side register terminations. The register functions to receive dial pulses or *Touch-Tone* pbone signals from either line-side or trunk-side circuits; after receiving tbe entire number, the register

signals the common control. The information in the register is then used, under the direction of the common control, to complete the required connections within the PBX. In the event that the called station or trunk is husy (including the husy-tone trunk, if provided), the register returns husy tone to the calling party. Upon connection of the register, the tip, ring, sleeve and "P-detect" leads are cut through to the calling line. This connection grounds the sleeve lead which operates the cutoff (CO) relay in the line circuit. The operation of the CO relay connects a tip, ring and sleeve lead to the associated electromechanical PBX which appears to this PBX as an origination. The voice PBX after finding the line returns dial tone to the station. If the first character "dialed" is the *Picturephone* prefix, #, the register detects this signal. Detection of the # causes the register to place a signal on the "P-detect" lead which in turn opens the tip and ring and grounds the sleeve lead to the electromechanical PBX. Grounding of the sleeve lead is done to provide the proper husy indication for incoming telephone calls to this station. The "P-detect" signal also allows the connection of the hattery feed and supervision circuits of the 850A to the line; the *Picturephone* call can then proceed. If the register detects that the first character "dialed" is not the #, it places a ground on the sleeve lead of the 850A and then releases from the connection. The call in this latter case will he processed as a telephone call by the associated PBX. In the event the 850A is modified as a stand-alone *Picturephone* System, the register returns dial-tone if the first character "dialed" is not a #. If telephone stations are connected to a stand-alone 850, voice calls must be preceded hy #.

The register is arranged to detect the # and to receive a three- or four-digit code for station lines; two- or three-digit code for conference calling; and a one-digit code for CO trunks and attendant trunks. The calling party has approximately 10 seconds to "dial" the first digit after the application of dial tone. If this 10-second interval is exceeded, the register drops the connection and allows the 701(757) PBX to time out and return fast husy tone (or attendant intercept). Subsequent digits must he "dialed" with a time interval no longer than 10 seconds hetween digits. If this interval is exceeded, after the #, the register times out and engages common control to connect the calling line to an idle attendant trunk on an intercept hasis. The "steering" circuit determines when all the digits have been registered; if a valid one-, two-, or three-digit code is received, the register recognizes the code, and engages common control to complete the call.

When digit registration is completed and common control engaged,

the register transmits the called number to common control. Common control then instructs the register to call back the calling line or trunk which is still connected to the register. On intercom calls, the terminating half of the call is established prior to call-back. Call-back identifies the calling circuit and allows common control to set up the remaining portion of the call and to signal the register to release the calling circuit. The register is then available for another call.

In the event that common control encounters a busy connection in attempting to set up a call, it connects the calling party to the busy-tone trunk. If the busy-tone trunk is busy or not provided, the common control reconnects the register to the calling circuit and instructs the register to transmit busy tone. After reconnection to the register, the calling circuit has approximately 10 seconds to abandon the call. If the call is not abandoned in this time interval, the register times out and engages common control to connect the calling line to an idle attendant trunk on an intercept basis.

### 2.4 *Network*

Topologically, the 850A PBX network is a three-stage, end-marked, switch for eight wires. The audio and video networks are distinct and separate and are master-slave related. The audio network control tests for idle paths and makes the path selection. When this function is completed identical paths are set up in the audio and video network. The audio network contains the tip and ring, a sleeve lead and a control lead (P-detect); the video network contains the transmit pair and the receive pair for the video portion of the call. Supervision of a *Picturephone* call is always done on the audio network.

There are two network sizes available for the 850A PBX; a 57-line size which has 64-line terminations and 32-trunk terminations, and an 89-line size with 96-line terminations and 48-trunk terminations. The difference of seven between total terminals and usable terminals are those assigned to registers, test line, attendant trunks and the recorded announcement trunk.

The switch apparatus is the 279-type ferreed. This ferreed family is pluggable and constructed on epoxy-clad metal circuit boards in order to meet crosstalk requirements. The ferreeds are available in $4 \times 4$, $4 \times 8$, and $8 \times 8$ sizes which contain four $4 \times 4$, two $4 \times 8$ and one $8 \times 8$ matrices per ferreed switch respectively. The 850A network uses the $4 \times 8$ and $8 \times 8$ switches and for the 89-line size network, a combination of these two is used to form a $12 \times 8$ switch for the secondary stage. Each crosspoint of the matrices has four dry-reed switch con-

tacts which are closed hy pulsing the associated solenoid. The pulse used in the 850A is 8 to 12 amperes and approximately 0.35 ms wide at 25 percent amplitude and 0.45 ms wide at the hase. Due to special magnetic properties of the switch, the contacts "remember" their last pulsed position—open or closed. The magnetic structure also insures that any previously operated contacts are released that share either a horizontal or a vertical with the pulsed path.

The ferreed operating characteristics, construction, and their operation in networks have heen discussed in detail in many previous publications.

When a path through the network is required, the common control marks the appearances on the line-side and trunk-side of the network. These marks (grounds) operate a unique set of relays that select the associated primary and tertiary switch. The network control also recognizes the request for the network and proceeds to select an idle path. Given a certain line-side appearance and a certain trunk-side appearance, there are four possible paths through the network. When according to a fixed preference an idle path has been tested and the secondary switch selected, the path is estahlished; the common control and trunk-side circuits are signaled that the connection has been made. When the path is pulsed, the appropriate crosspoints are closed and any interfering crosspoints are released; the network operation is then completed. If none of the four paths are idle, the common control is given a no-link-availahle (NLA) signal.

### 2.5 *Trunk and Attendant Facilities*

Since the trunk circuits of the 850A perform the same functions as in any other PBX system, their operation is discussed in general terms as relating to the 850A PBX. All the trunk circuits use a combination of integrated circuit gates, discrete transistors, and miniature relays.

#### 2.5.1 *Intercom Trunks*

Intra-PBX *Picturephone* calls are completed through a two-port intercom trunk which provides all standard audio alerting and supervisory functions as well as a four-wire video connection. A Video Supervisory Signal (VSS) is also applied to activate the calling station's *Picturephone* set and to cause a distinctive alerting signal at the called station.

#### 2.5.2 *Central-Office Trunks*

Incoming and outgoing *Picturephone* calls to a *Picturephone*-

equipped central office are completed through the two-way central-office trunk. The trunk is a five-port circuit with one port to the central office, one to the attendant, two to the 850A network, and one to the adjunct telephone system. In addition to providing the required video connections and VSS, the trunk circuit makes a connection to the video continuity test (VCT) equipment at the beginning of all incoming and outgoing calls. Circuit and feature options such as D.I.D. or ground-start type trunk circuits can be provided, Call-Transfer-Individual or Call-Transfer Attendant, and the proper interface circuit with either the 701B step-by-step PBX or 757A crossbar PBX are provided by the proper plug-in boards. The central-office trunk circuit handles all direct-dialed incoming and outgoing central office calls, incoming directory-number calls to the attendant, incoming calls completed by the attendant to either *Picturephone* or telephone stations, and Call-Transfer calls (either direct-dialed or attendant-handled) to either *Picturephone* or telephone stations.

#### 2.5.3 *Attendant Trunk*

The 850A is also equipped with a two-port attendant trunk which is used to complete *Picturephone* station-to-attendant calls or attendant-originated calls. Calls to the attendant may be extended by the attendant to either the *Picturephone* central office or to other *Picturephone* stations, and attendant-originated *Picturephone* calls may be made to either the central office or to *Picturephone* stations. The attendant trunk has no connection to the adjunct telephone system.

In an adjunct installation with either a 701B or 757A telephone PBX, the normal procedure to provide attendant service will be to equip one or two existing telephone attendant consoles for *Picturephone*. Two position applique circuits (one for the 701B and one for the 757A) have been designed to interface the lockout and control signals between the existing attendant position equipment and the 850A trunk circuits. This is necessary since the signals generated by the existing 48-volt electromechanical equipment are not compatible with the 850A trunk circuitry, which consists of 24-volt solid-state logic and miniature relays. In a Stand-Alone system, an 850A position circuit must be added to provide the functions normally provided by the telephone adjunct position equipment.

#### 2.5.4 *Miscellaneous Trunks*

Additional trunks employed by the 850A include the busy tone trunk and the intercept-recording trunk.

### 2.6 *Maintenance*

Special maintenance features such as, in-service checks, and additional maintenance features beyond those found in similar PBXs have been incorporated in the 850A. Maintenance is performed by the use of two major circuits; the Maintenance Test Circuit and the Fuse, Alarm, and Emergency Transfer Circuit.

#### 2.6.1 *Maintenance Test Circuit*

The functions performed by the Maintenance Test Circuit (MTC) are: (*i*) monitoring the operational status of the 850A system via status indicating lamps located on the System Status Indicator Panel (SSI); (*ii*) manual selection of a specific switching path and/or circuit for testing the switching capability of the system; (*iii*) manual or automatic connection of the selected circuit to the test line; (*iv*) manual override, reset or reset override maintenance functions for testing the common control circuit; (*v*) path jack access to all *Picturephone* video equalizers; and (*vi*) providing maintenance routines such as: (*a*) inhibit network relay operation, (*b*) force a register timeout condition, (*c*) cause transfer of all *Picturephone* stations from *Picturephone* service to audio only service, (*d*) disable *Picturephone* station line transfer function caused by a major circuit failure, (*e*) disable all alarm signals generated to local and remote facilities, (*f*) remove the "loop back" function of calls directed to the attendant to aid in testing and lineup procedures, and (*g*) reset the video-continuity test (VCT) failure circuit alarms.

In addition to these maintenance functions, the MTC provides a termination for test calls which originate on a No. 23A testboard, No. 15A local test desk, central-office master test frame or local PBX test line.[6,7] The use of this equipment allows the testing of the audio and video connection between the central office and the PBX and within the PBX. Also, lead terminations containing circuit busy/idle or circuit seizure information are grouped together on connectors for use with external traffic measuring equipment.

#### 2.6.2 *System Status Indicator*

In general the circuits, keys, etc., on the MTC are not unique and their operation is self-explanatory by their function. However, the System Status Indicator Panel (SSI) is normally not used in PBXs. The SSI consists of switches and indicator lamps connected to the common control, register, and switching network via Darlington-type transistor amplifiers. Positive signals received from the monitored

circuits reflect the dynamic operation of the circuit as it performs its switching function. Therefore, during normal operation of the system circuit switching operations will produce short duration lamp indications (flashes), indicating which circuit or path or which function was performed during this switching operation. In the event of circuit failure, one or more of these indicators will remain lighted, indicating in which mode the system is locked. Lamp indications are provided for each of the common control modes discussed earlier; additional indicators are provided for register-busy for each of the maximum of three registers, read-out indication of the registers, and a *Picturephone* call "detect" of the registers which indicates that an # signal has been detected by the respective register and that it has initiated a release signal to disconnect the audio PBX from the originating line circuit.

2.6.3 *Fuse, Alarm and Emergency Transfer*

The function of the Fuse, Alarm and Emergency Transfer Circuit (FAET) is the distribution of dc power, ring and tone, and interrupted signals to all 850A circuits associated with the audio PBX system. This circuit also provides the necessary alarm indications and station line transfer functions in the event of power, fuse, or circuit failure within the 850A PBX System.

The dc power for the switching circuits (+24, −24, and −48 volts) is distributed through alarm indication fuses of the Power Distribution and Fuse Circuit. The dc power (−24 V) for the video equalizers is distributed through alarm indication fuses of the equalizer Fuse Alarm Circuit located on the equalizer bays.

PBX *Picturephone* circuit failures are classified as causing major or minor service interruptions. Major circuit failures are those that result in the complete loss of the switching capability of the 850A. Such interruptions, caused by certain fuse failures, loss of dc voltage from the associated power supplies, or failure of the common control will activate related alarms in the 850A and associated audio PBX, and terminate *Picturephone* service by causing all *Picturephone* stations to be transferred to audio telephone service. Minor circuit failures affecting individual *Picturephone* circuits but not affecting the switching capability of the 850A will activate related alarms in the 850A and the associated PBX.

All alarms associated with the video transmission are also indicated on the MTC. In addition, a distinctive *Picturephone* alarm indication (red lamp) is presented at the associated telephone console. This dis-

tinctive *Picturephone* alarm is also transmitted to the central office via alarm extension leads, when provided, and is interrupted at a 60 IPM rate.

### 2.7 *Miscellaneous Circuits*

In addition to the major circuits of the 850A PBX discussed above, there are some smaller, hut important, circuits necessary for the proper operation of *Picturephone* service hy the 850A.

#### 2.7.1 *Video-Continuity Test (VCT) Circuit*

When a central office trunk is connected to the calling station, a video-continuity test (*VCT*) is made from the trunk circuit through the network to the calling line to insure the proper transmission quality of the video quad. The VCT is made only on connections where charging will occur; i.e., intercom calls do not have a VCT. When the VCT verifies the transmission quality of the loop, the central-office trunk circuit then cuts the station through to the central office. Should the loop fail the VCT, an alarm is registered, the connection hetween the line and trunk released, and the line is marked again. The common control then marks an intercept-recorded announcement trunk circuit on the trunk side of the network. The calling line is then connected to this trunk which returns a recorded message advising the calling party that the call cannot he completed on a video hasis.

The VCT circuit contains a 12 kHz signal generator and window detector; the generator delivers the precisely controlled level signal to the central office and attendant trunk circuits. The window detector receives the looped-hack signal from the trunk circuit; if the received signal lies within the range of +1.8 to −3.0 dB of the transmitted signal, the VCT circuit signals "pass." If the received signal is outside this range, then a fail signal is generated causing station reroute to the recorded announcement. An exception to this is in a station-to-attendant call, in this case the call is allowed to complete but the VCT fail signal inhihits the attendant from extending the call to the central office.

#### 2.7.2 *Video Supervisory Signal (VSS) Circuit*

Following a successful VCT, a video supervisory signal (VSS) is applied 100 ms before ringing at the trunk on the video quad. The VSS is required to turn on the *Picturephone* display unit, thus prohihiting the use of the set without estahlishing a valid *Picturephone* call. VSS

and the ringing signal are joined to form a composite signal which activates a tone ringer producing a distinctive tone indicating the *Picturephone* status of the incoming call.

One VSS generator circuit is used in the 850A and it is the same as incorporated in the *Picturephone* set.[4] The VSS signal is supplied to the set by the trunk circuits through a distribution amplifier. This VSS circuit is also alarmed in case of failure.

2.7.3 *Video-Image-Generator*

The Video-Image-Generator (VIG) equipment is provided as an option on the 850A PBX; the function of this equipment is to transmit a fixed image to a caller while the attendant processes his call. An incoming central-office call picked up by the attendant will normally transmit the attendant's image if the attendant is equipped with a *Picturephone* set; if the attendant is not equipped, then the caller will have raster but a blank screen. If the 850A customer elects to have a VIG, then when the attendant places the caller on "hold" a fixed image supplied by the customer is transmitted to the calling party until he is connected to his requested party.

The VIG is a combination of a *Picturephone* display unit and a 35-mm projector packaged as a single unit. A regular 35-mm slide can be inserted into the projector to provide the transmitted image. This equipment can be located remotely from the 850A but within the confines of *Picturephone* set transmission limitations.

## III. APPARATUS AND EQUIPMENT

3.1 *Logic*

The basic logic element used in the 850A is the 30A RTL, quad gate, 24-volt, hybrid-integrated circuit (HIC), presently being manufactured by the Western Electric Company.

In the early design stages of the 800A PBX many types of logic were investigated. Because of the relatively low line size (80 lines), the 800A did not require the switching speed of devices used in large electronic systems. In addition, the 800A design called for the use of miniature flat spring relays which operate at a nominal 24 volts. Therefore, a family of RTL logic gates using a 24-volt collector supply was developed. The use of such a logic gate provided for a good marriage between the solid-state circuits and relays, and allowed the use of only one supply voltage.

The family of RTL gates developed were of five basic types, coded

17A, 18A, 19A, 20A, and 21A with additional subgroups B and C on the 17 and 18 types. Tbese different gate codes identified the number of resistor inputs. Each logic gate was constructed of tantalum deposited resistors and a discrete-type 16J transistor mounted on a ceramic cbip.

Witb the advent of integrated circuit technology in Western Electric Company production, a hybrid-integrated circuit (HIC) gate was developed to replace the 17A-21A gates. This new quad gate, type 30A, is a 24-volt HIC and, as shown in Fig. 3, consists of two two-input, one four-input, and one five-input RTL gates. A 30A circuit package is formed by bonding a quad transistor chip to a $\frac{1}{2}$ by 1 inch ceramic substrate which contains 17 deposited tantalum resistors; two views of tbe package are shown in Fig. 4. The four base leads are brought out to external terminals so that additional inputs may be added to any gate by means of discrete resistors.

### 3.2 *Circuit Packs*

The 30A Gates, miniature relays and other miscellaneous discrete components are mounted on 8 by 8 inch epoxy-coated metal printed wire boards which, in turn, plug into 23-incb board carriers. These boards, as sbown in Fig. 4, are the same size as used throughout the 800A PBX. The use of large boards reduces system wiring, provides functional modularity, flexibility, ease of growth, and easy replacement for maintenance. "Plated-through" boles, which are easily obtained because of a characteristic of the epoxy, are utilized to provide printed-circuit paths on both sides of the board. The circuit devices mounted on the board are protected by a ventilated plastic cover on the board. Each cover includes a plastic ejection lever molded as part of the cover for easy removal of the circuit pack from its carrier.

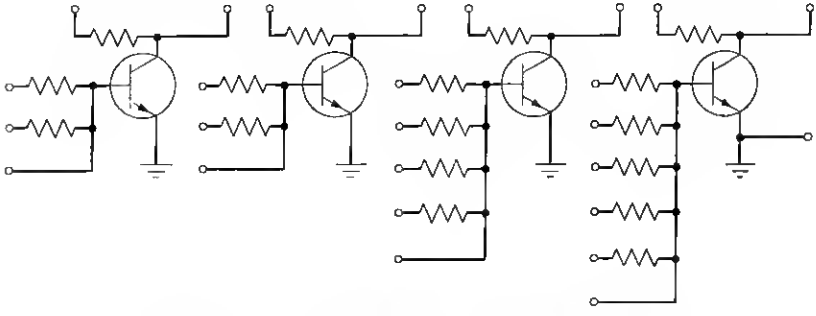

Fig. 3—Schematic representation of the 30 HIC gate.

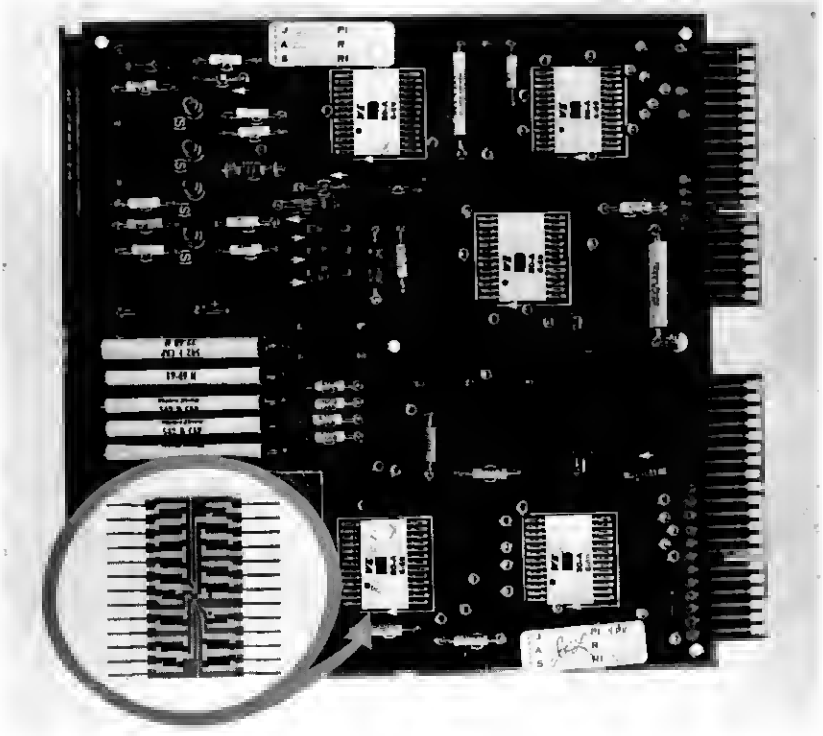

Fig. 4—Typical 850A circuit pack with HIC devices.

The circuit pack carriers (Fig. 5) are self-supporting and bolted to the frames. These carriers are the same as those used in the 800A but are cut to a 23-inch size for frame mounting. The carriers are aluminum die cast with identical top and bottom plates with molded-in slots for the circuit packs, ventilation holes and mounting bosses for the snap-in plastic 100-pin connectors. Each carrier has a circuit pack designation strip that also serves as a gravity-operated locking bar to prevent circuit-packs from vibrating out of their connectors.

### 3.3 *Network*

The ferreed bottles are also mounted on epoxy-clad plug-in printed wire boards for use in the 850A PBX. The use of the metal board in this application provides capacitive shielding (by grounding the board) which gives the 850A switching network excellent crosstalk protection. The orientation of the printed-circuit paths were subjected

to many tests and then optimized to achieve good characteristics for such transmission characteristics as crosstalk and impulse noise for the one-MHz video transmission bandwidth.[2]

The use of pluggable ferreeds allows the selection of the network of a particular line and trunk size at initial installation but growable at some future date by the addition of ferreed packs. Since, as also stated above, two 4 × 8 matrices are incorporated in one ferreed switch pack, line and trunk terminals are growable in groups of 16 terminals. The secondary stage of the 3-stage network is equipped for either the maximum 57-line or 89-line size network. The 57-line size network can contain a maximum of 16 (8 audio, 8 video) ferreed switches; the 89-line size can be equipped with 32 ferreed switches.

A "patch-field" is associated with the switching network to add further system flexibility. This feature permits adjusting the network traffic distribution in the field by rearranging the plugs connecting each line and trunk to the network on the patch-field.

### 3.4 *Equipment Arrangement*

A complete 57-line system, including power, is rack-mounted on five standard 701-type 23-inch, 7-foot frames as shown in Fig. 6. The carriers are equipped with the number of circuit packs required for a particular customer order. An 89-line system requires six frames. In order to grow from a 57-line system to an 89-line system, the bay con-

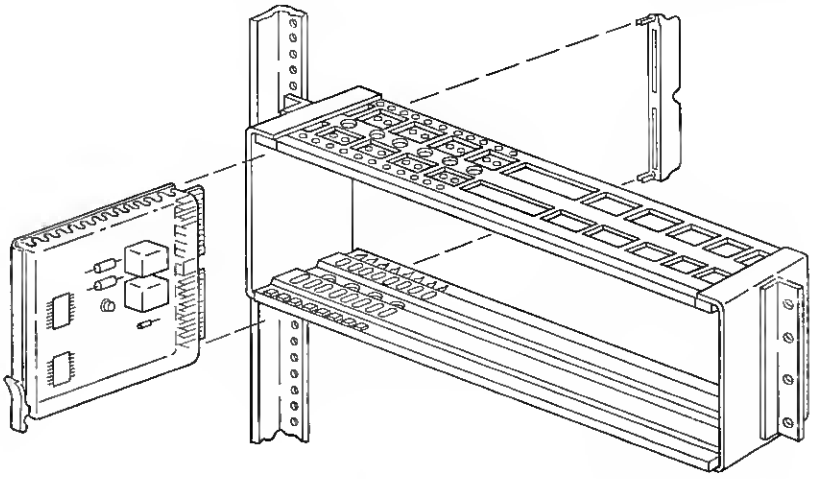

Fig. 5—Die-cast carrier for the circuit packs.

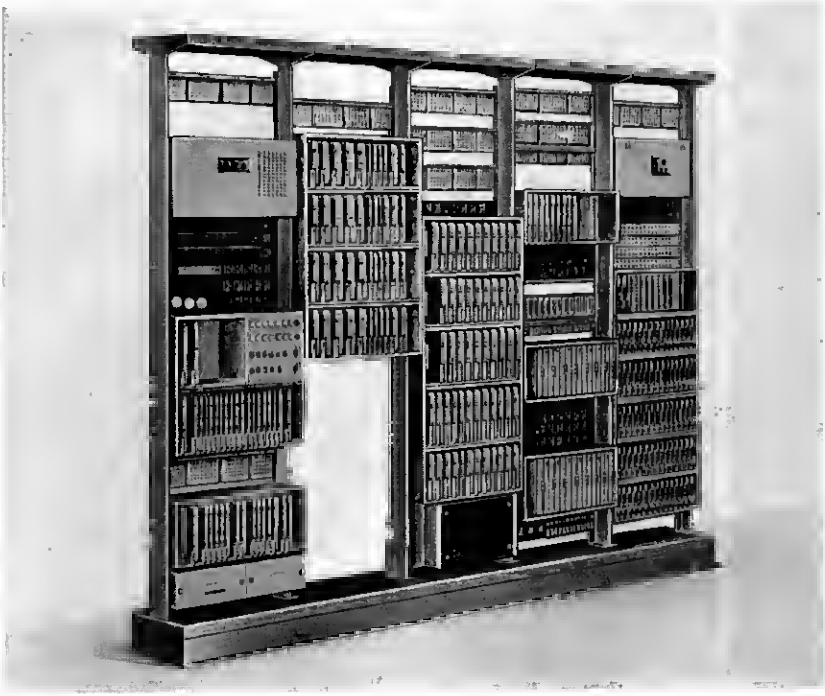

Fig. 6—Equipment arrangement of the 850A PBX.

taining the switching network and video switches is substituted with a bay containing an 89-line network and a bay added to the line up containing the additional video switches required for this line size.

Referring to Fig. 6 and going from left to right, the first bay contains the +24 volt and −48 volt power supply, the SSI, MTC panel, common control and registers. Bay B, the next bay in line, contains the attendant and central-office trunk circuits. Bay C contains the line circuits and intercom trunks. The switching network, VSS, and VCT circuits, and video switches are on Bay D, and Bay E contains the −24 volt supply, fuse and jack panel, and the video-equalizers.

The bays are interconnected by plug-ended cables which allow the test of the complete system at the manufacturing site and fast installation at the customer's location. Connections to the 701- or 757-type PBXs are made to the appropriate wire-wrap terminals located at the top of the bays.

IV. ACKNOWLEDGMENTS

The author wishes to acknowledge the 850A circuit design contributions of M. A. Hoffman, G. A. Lesser, C. C. Nielson, A. P. Ryan, III, L. E. Saltzman, and G. A. Scharg and the assistance of F. Lukas.

REFERENCES

1. Breen, C. "The *Picturephone*® System: Customer Switching Systems," B.S.T.J., this issue, pp. 553–565.
2. Brown, H. E., "The *Picturephone*® System: Transmission Plan," B.S.T.J., this issue, pp. 351–394.
3. Baker, D., et al., "Electronic Switching for Small PBXs," Bell Laboratories Record, *45,* No. 2 (February 1967), pp. 49–56.
4. Cagle, W. B., Stokes, R. R., and Wright, B. A., "The *Picturephone*® System: 2C Video Telephone Station Set," B.S.T.J., this issue, pp. 271–312.
5. Brown, J. M., "The *Picturephone*® System: Baseband Video Transmission on Loops and Short-Haul Trunks," B.S.T.J., this issue, pp. 395–425.
6. Favin, D. L., and Gilmore, J. F., "The *Picturephone*® System: Line and Trunk Maintenance Arrangements," B.S.T.J., this issue, pp. 645–665.
7. Dougherty, H. J., Peterson, E. B., and Schachtman, M. G., "The *Picturephone*® System: Maintenance Plan," B.S.T.J., this issue, pp. 621–644.